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(54) Abstract Title
Removable suction anchor

(57) A subsea suction anchor for anchoring in a subsea surface comprises a plurality of portions 36, 37 and 38 which are capable of transformation from a first configuration Fig 9 in which the portions are substantially adjacent to each other to a second configuration Fig 11 in which the portions are substantially spaced apart from one another, such that the anchor can be removed from the subsea surface. A method of using said anchor is also claimed. The suction anchor may have a substantially cylindrical body having a longitudinal axis, with the portions comprising discrete longitudinal lengths of the body.

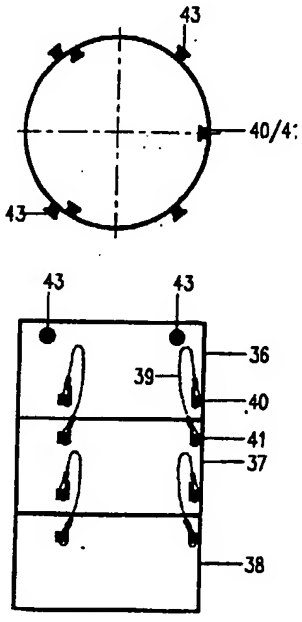

FIG 9

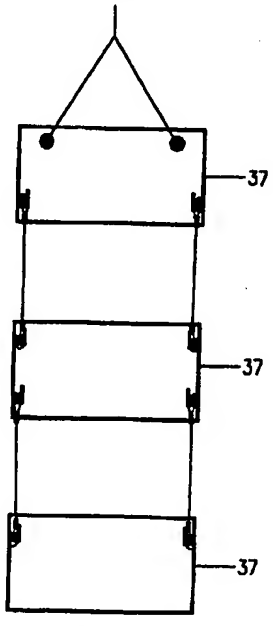

FIG 11

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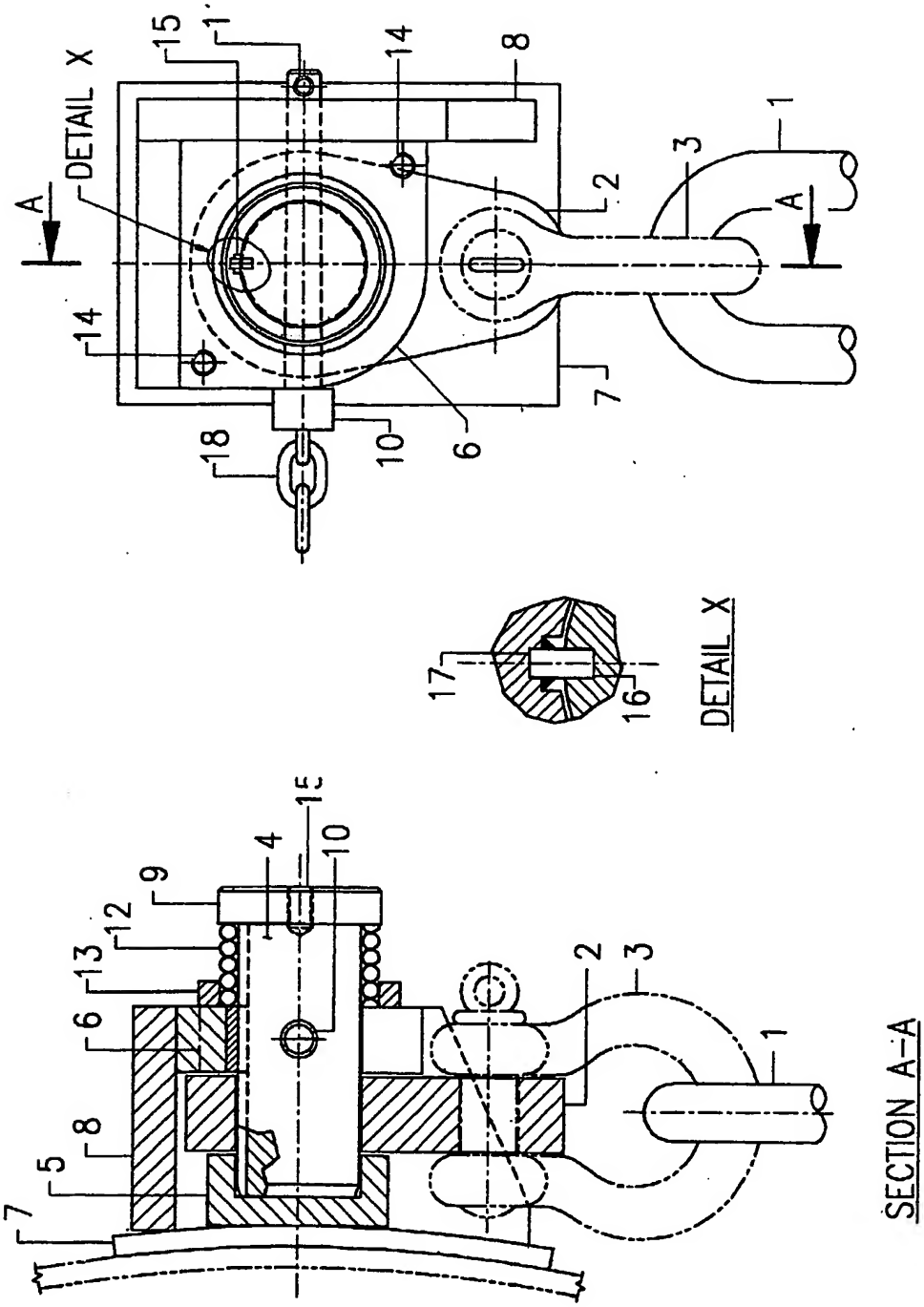
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SECTION A-A

FIG 1

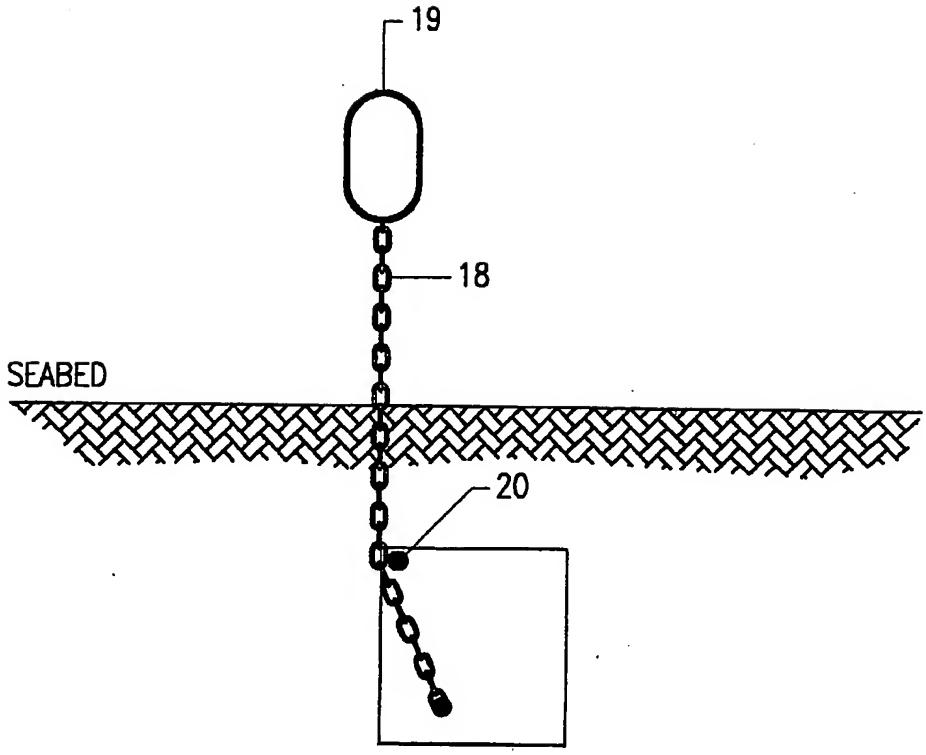

FIG 2

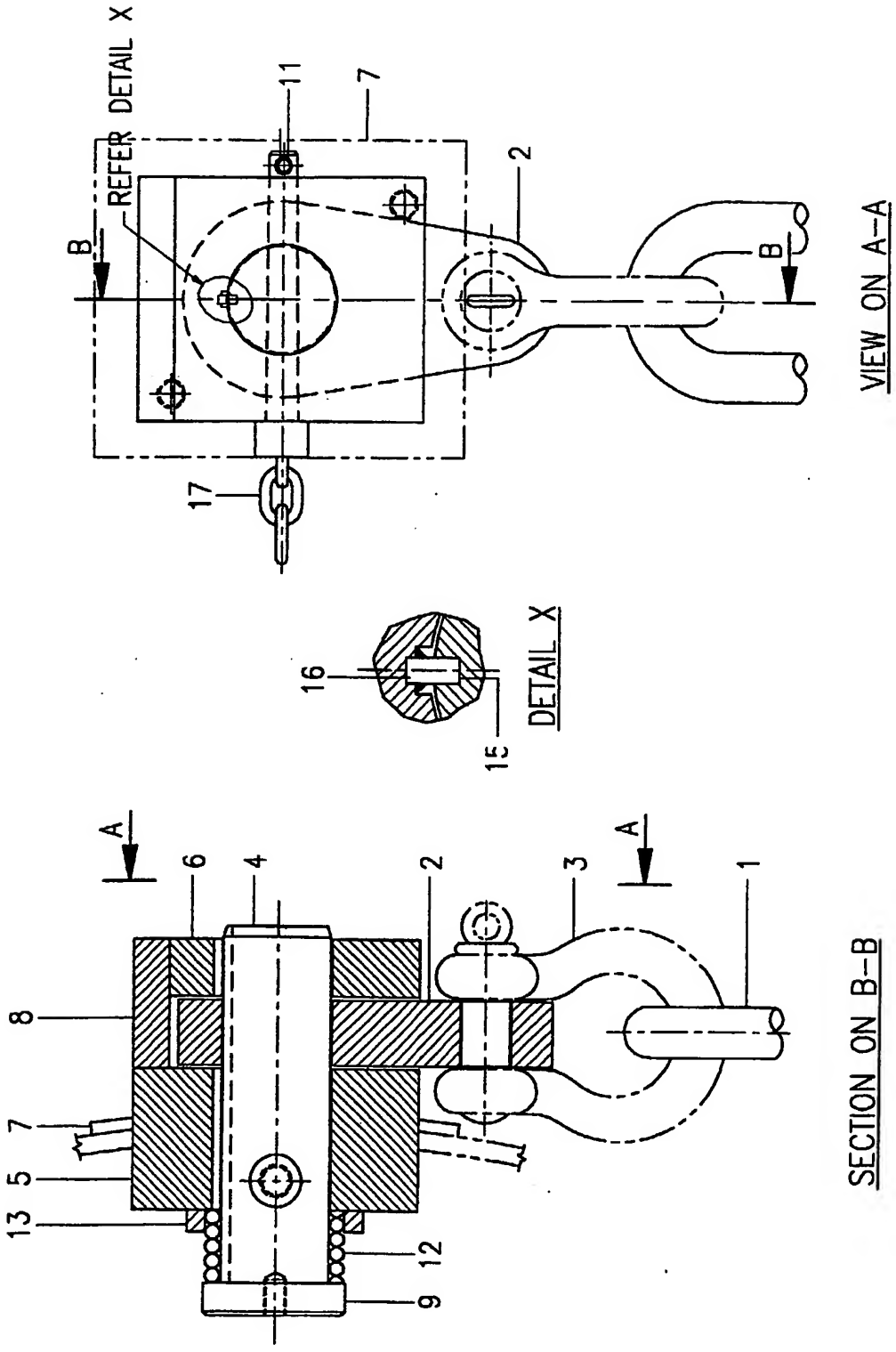
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FIG 3

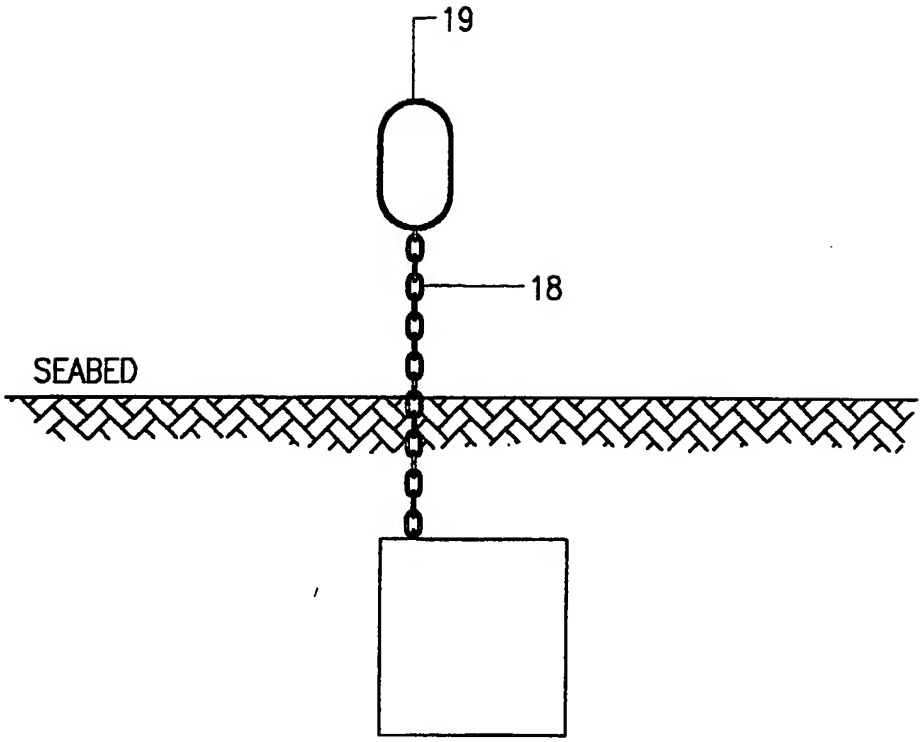


FIG 4

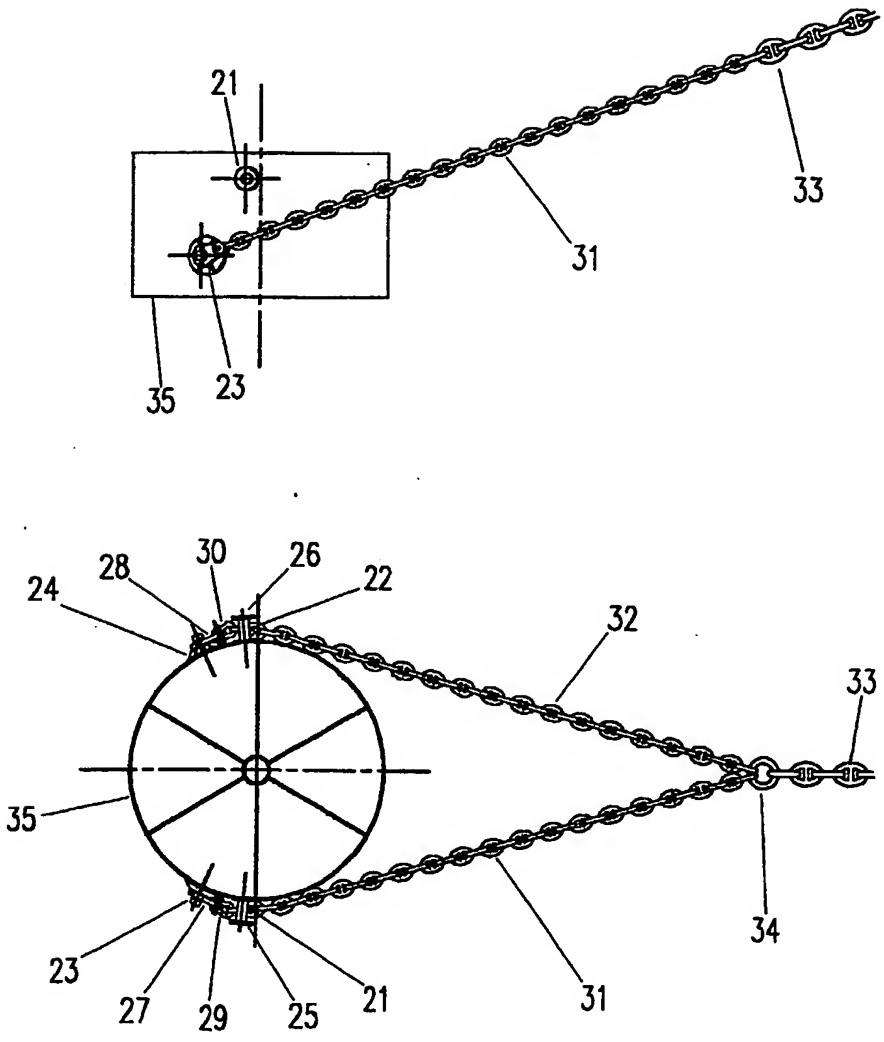


FIG 5

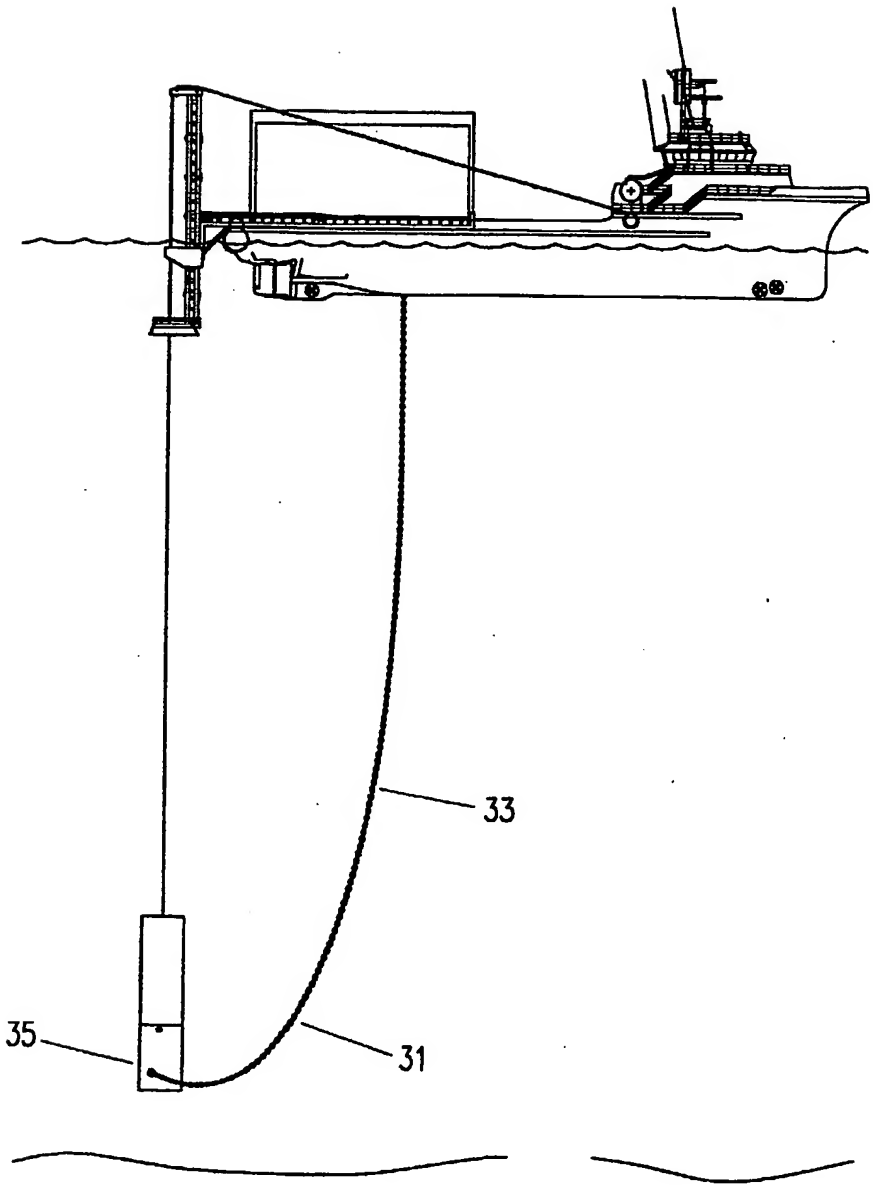


FIG 6

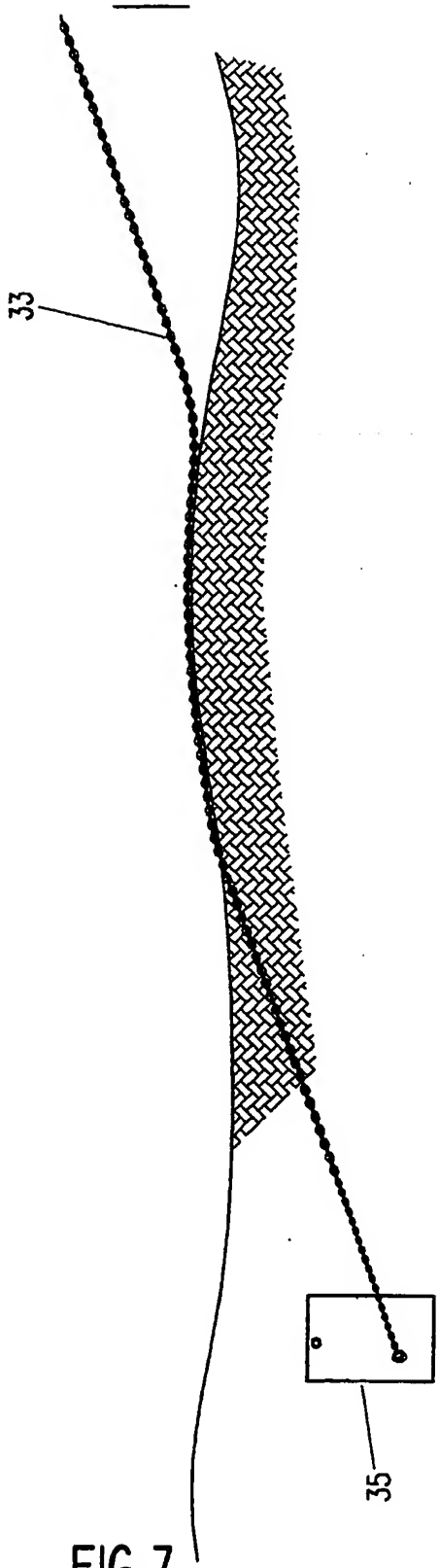


FIG 7

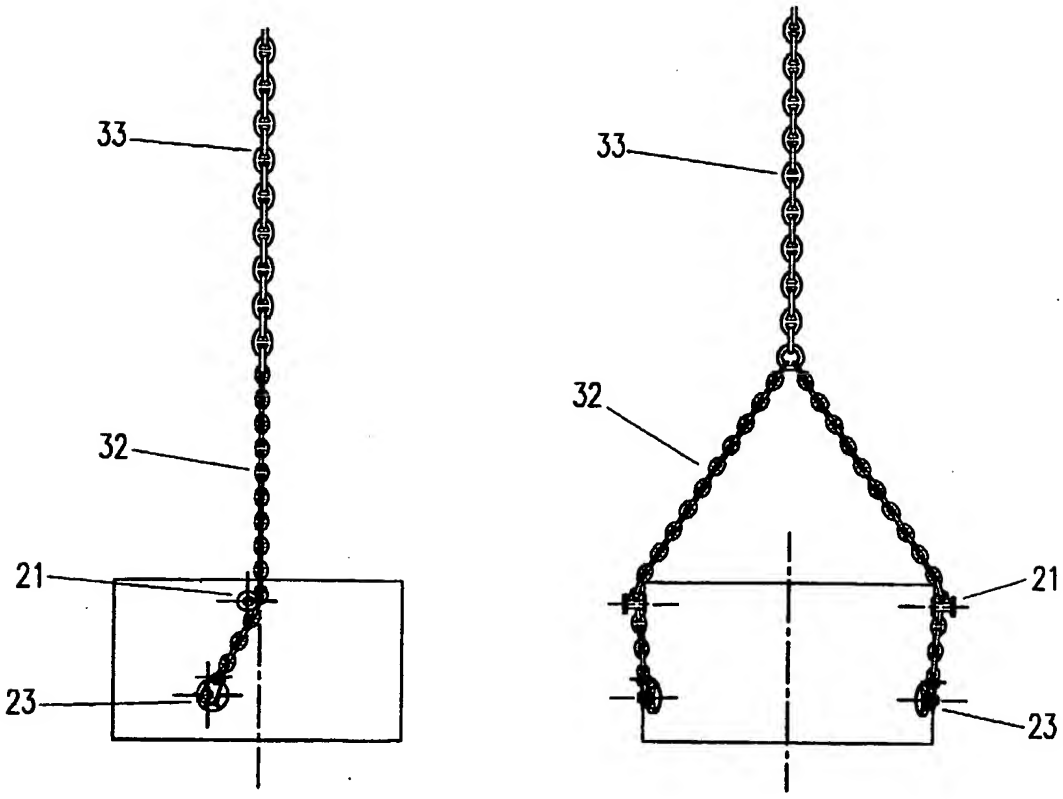


FIG 8

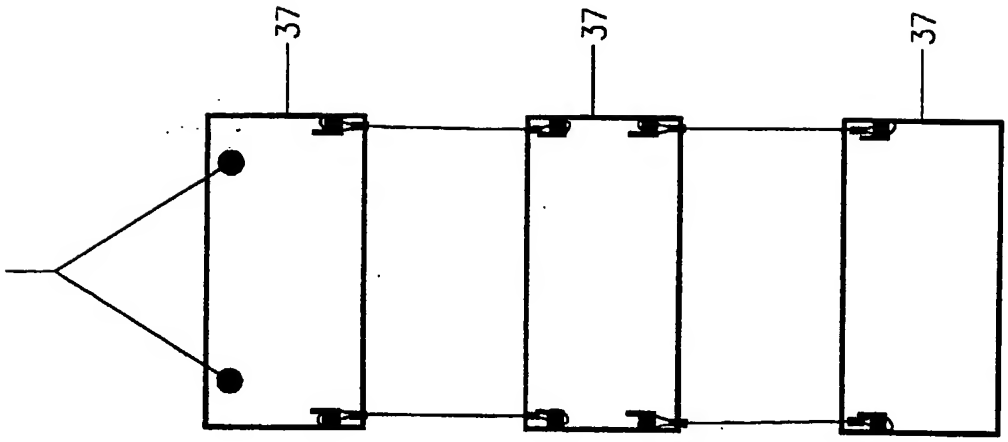


FIG 11

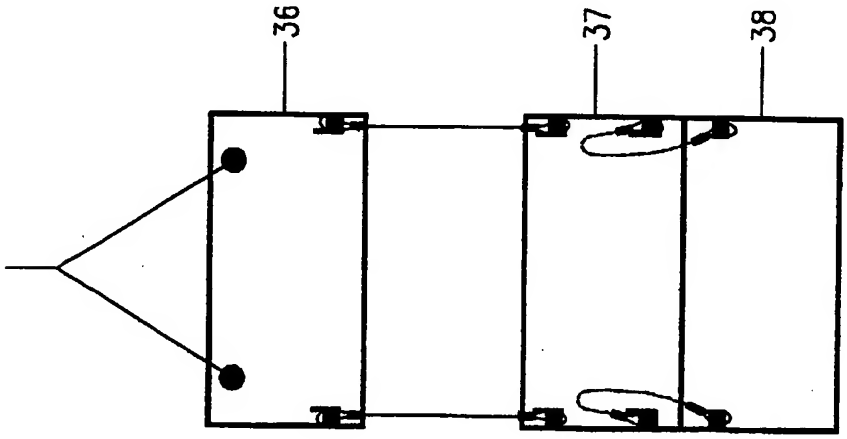


FIG 10

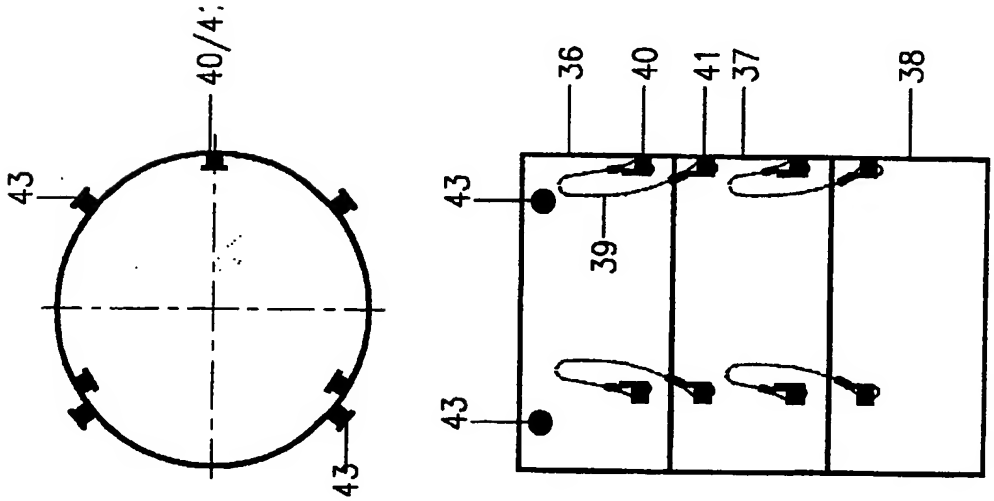


FIG 9

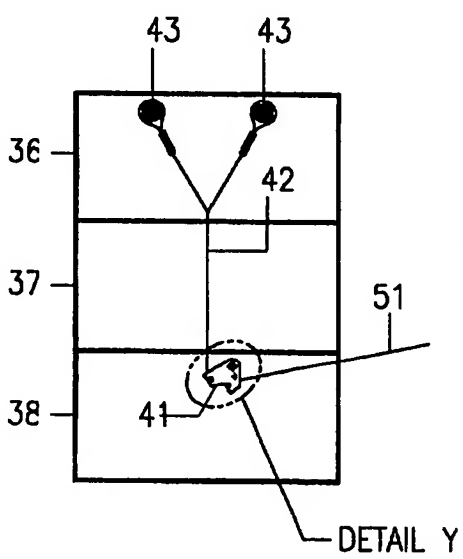
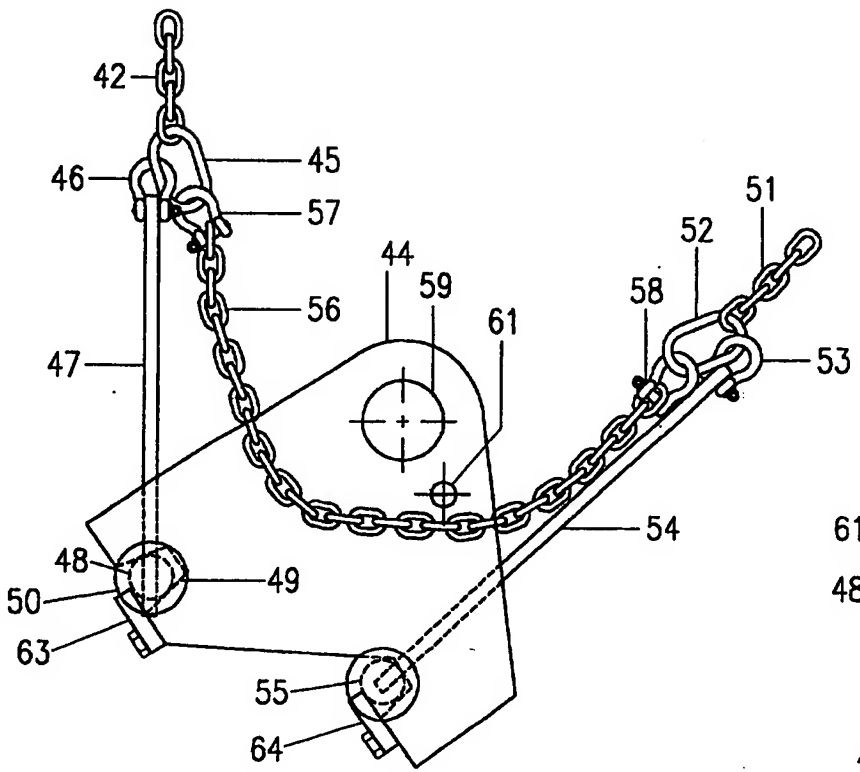


FIG 12



DETAIL Y

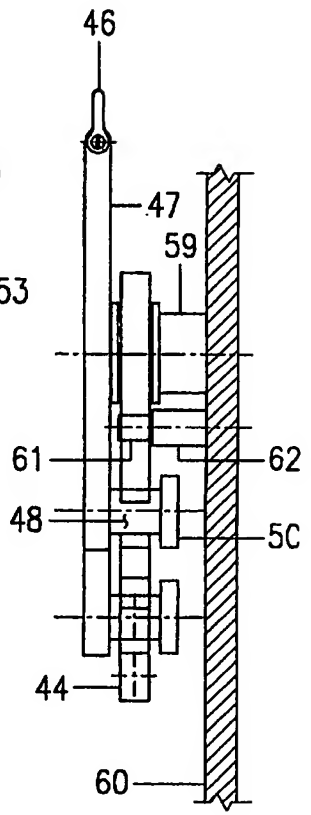


FIG 13

Removable Suction Anchor

The invention relates to a removable suction anchor with minimal subsea intervention or without the need for subsea intervention. The invention in its various forms is particularly suited for use with anchors installed by methods other than by drag embedment where the cost of vessel deployment and the retrieval process is usually more than the capital value of the anchors themselves.

The present invention describes methods of anchor retrieval or abandonment which do not require expensive subsea intervention. They will be useful especially (though not exclusively) in connection with the disconnection and recovery of mooring chains and ropes and rigging from fully buried suction anchors.

According to a first aspect of the present invention there is provided a subsea suction anchor apparatus which, in use, is anchored in a subsea surface, the suction anchor comprising a plurality of portions which are capable of transformation from a first

configuration in which the portions are substantially adjacent one another to a second configuration in which the portions are substantially spaced apart from one another such that the suction anchor is capable of being removed from the subsea surface.

According to a second aspect of the present invention there is provided a method of removing a subsea suction anchor from a subsea surface, the method comprising providing a plurality of suction anchor portions which are capable of transformation from a first configuration, in which the portions are substantially adjacent one another and in which the suction anchor is capable of being used as a suction anchor, to a second configuration in which the portions are substantially spaced apart from one another, and transforming the suction anchor from the first to the second configuration.

Mooring Anchor Disconnection System

This is a system of devices and arrangements to enable a mooring line or mooring line bridle to be disconnected from an anchor which is a member of a vessel mooring array when extraction of the anchor is not required or is not possible. The anchor may be a suction anchor with a fully buried lower section or may be a traditional suction anchor or a plate anchor or traditional pile.

A specific embodiment of the system for use with a suction embedded caisson anchor will now be described by way of an example with reference to the accompanying drawings in which:

Fig. 1 shows the general arrangement of the invention with an externally mounted spring-loaded pin assembly.
Fig. 2 shows an external rigging arrangement.
Fig. 3 shows an alternative arrangement in which the spring, taper pin, and stubshaft head are on the inside of the suction anchor can instead of the outside.
Fig. 4 shows an internal rigging arrangement.

The mooring line bridle wire or chain (1) is connected to a rotating padeye unit (2) by a shackle (3). The rotating padeye unit (2) is mounted on a stubshaft (4). The stubshaft (4) spans in double shear between two journal blocks (5) and (6). The inner journal block (5) is welded to a doubler plate (7) which in turn is welded to the suction anchor can. The outer journal block (6) is supported on and welded to a steel cylinder or box (8) which is in turn welded to the doubler plate (7). Slightly more than one quarter (90°) of the cylinder or box (8) is cut away or open to allow access of the chain (1) from directions ranging from horizontal to vertical. The stubshaft (4) extends through and projects beyond the outer journal block (6) and terminates in a head (9). The stubshaft (4) is held in position by a tapered pin (10) which passes

through the journal block (6) and the stubshaft (4) and the cylinder or box (8) and is in its turn held in position by a shearpin (11). A helical spring (12) is mounted on the stubshaft between the outer journal block (6) and the stubshaft head (9). A retaining ring (13) may be welded to the outer journal block to assist in locating the spring during assembly. The spring (12) is compressed by forcing the stubshaft home with the aid of a hydraulic jack and strongback bearing against tension bolts set temporarily into the tapped holes (14). The stubshaft (4) has a keyway (15) which engages with a key (16) on the outer journal block (6) in order to ensure that the holes in the stubshaft and journal block are properly aligned to accept the tapered pin. The tapered pin (10) is then inserted and the shearpin (11) in its turn is inserted into the tapered pin to hold it in place. The jack can now be released and the bolts removed from the tapped holes. An actuation chain (18) is attached to the head of the tapered pin (10). The actuation chain terminates in a subsea buoy (19) as indicated in Fig. 2. The actuation chain (18) is sufficiently long to enable the buoy (19) to remain well above seabed level after the suction anchor has been installed.

When the suction anchor has fulfilled its purpose and is to be abandoned, the mooring is disconnected by attaching a winch line from a surface vessel to the actuation chain (18) with the aid of a WROV (Working Remotely Operated Vehicle) and applying a

tension which exceeds the shearing load of the shearpin (11) and the friction between the tapered pin and the stubshaft and journal block and thereby extracts the tapered pin (10) allowing the spring to push the stubshaft (4) out from the journal blocks (5) and (6) sufficiently to release the rotating padeye unit (2). The mooring chain and bridle (1) with the shackle (3) and rotating padeye (2) can now be recovered leaving the suction anchor in place.

An alternative arrangement in which the spring, taper pin, and stubshaft head are on the inside of the suction anchor can instead of the outside is shown in Fig.3.

Mooring Line Removal Together with a Caisson or Plate Anchor Without Subsea Intervention: Method 1

This is a system of devices and arrangements to enable a mooring line to be recovered together with its associated caisson anchor or plate anchor which is a member of a vessel mooring array to be extracted from the seabed by vertical tension on the mooring line from a surface recovery vessel when its use as a mooring anchor at the location in question has come to an end.

A specific embodiment of the system for use with a suction embedded caisson anchor will now be described by way of an example with reference to the accompanying drawings in which:

Fig. 5 shows the general arrangement of the system.

Fig. 6 shows a modular suction anchor being deployed to the seabed with the mooring chain rigged.

Fig. 7 shows the suction anchor and mooring chain in normal use.

Fig. 8 shows the mooring chain engaging in the upper bosses prior to removal of the anchor.

Referring to the drawings, a pair of bosses (21) and (22) is attached to the outside of the suction anchor close to its top on opposite meridians perpendicular to the direction of the mooring line when it is in use as such. A second pair of bosses (23) and (24) is attached to the outside of the suction anchor slightly below its mid-height on meridians which are offset from the meridians of the upper bosses in a circumferential direction away from the direction of the mooring line when it is in use as such. The upper bosses (21) and (22) are fitted with widened heads (25) and (26). The lower bosses are fitted with steel rotating padeye plates (27) & (28) and shackles (29) and (30) securing the mooring bridle chains (31) and (32). The bridle chains are connected to the lead chain or rope of the mooring line (33) via a standard master link (34).

The sequence of operation is shown in Figs. 6, 7 & 8. The suction anchor is deployed to the seabed

with the mooring line attached to it via the bridle chains. The mooring line leader (chain, wire rope, or polymer rope) hangs from the surface well clear of the suction anchor deployment winch line and on its intended operational azimuth from the suction anchor axis. When the suction anchor has been installed into the seabed, the mooring line leader is buoyed off to await the arrival of the floating unit which is to use the mooring. When the floating unit has arrived and its mooring cable has been run out and connected to the mooring line leader, the mooring table is tensioned. This brings the bridle into the configuration shown in Fig. 7. This is the operational configuration of the anchor and mooring.

When the floating unit has completed its task at the location and the mooring cable has been disconnected from the mooring line leader, the leader and anchor are recovered by an anchor handling tug or other suitable vessel. This is done by attaching the vessel winch line to the leader and applying a vertical tension. The configuration of the bridle changes to that shown in Fig. 4. The bridle chains come into contact with the upper bosses. In this way the resultant vertical force is applied on the axis of the suction anchor. Any small deviation of the suction anchor from the vertical during extraction will thus result in an opposing couple formed by the applied force and the vertical soil resistance so that the deviation will be self-righting.

When the anchor has been extracted it may continue to hang vertically from the mooring line or may tip and hang with its axis horizontal. Its orientation is immaterial to its recovery over the stern roller of the vessel.

Mooring Line Removal Together with a Caisson or Plate Anchor Without Subsea Intervention: Method 2

This version of the invention is a system of devices and arrangements to enable a caisson anchor or plate anchor to be extracted from the seabed without subsea intervention. This is achieved by pulling vertically on the mooring line. The pull forces required are kept within the limits of vessels and winches of limited capacity by arranging for each section or ring of the anchor to be extracted from the seabed one after the other so that the force required to pull out the whole anchor at once is not needed.

A specific embodiment of the invention for use with a specially configured suction embedded caisson anchor will now be described by way of an example with reference to the accompanying drawings in which:

Fig. 9 shows the general arrangement of the invention in elevation and plan.

Fig. 10 shows the general arrangement of the invention with the top ring section pulled from the remaining two sections of the anchor.

Fig. 11 shows the general arrangement of the invention with the all ring sections separated.

Fig. 12 shows the general arrangement of the invention with chains and rotating link plate attached.

Fig. 13 shows the detail of the rotating link plate in plan and elevation.

The rings (36), (37), and (38) of the lower anchor (three rings in this example) have brackets (40) and (41) between which chains (39) are connected. The mooring line bridle is attached to two pairs of trunnions (43) on the upper ring. When the mooring line is pulled vertically, the upper ring (36) is lifted through the soil. The length of the connecting chains (39) between the upper ring (36) and the next ring (37) is selected so that the first ring (36) is clear of the seabed before the chains become taut and the second rings starts to be lifted. Similarly the length of the connecting chains between ring (37) and ring (38) is selected so that ring (37) is clear of the seabed before ring (38) starts to be lifted. In this way only one ring has to be moved at a time and the required tension is very much less than would be the case if all rings were lifted together. This keeps the anchor extraction operation within the winch capacity of a larger number of vessels.

In order to ensure that the mooring line is effectively attached to the suction anchor at the

correct height during its functioning as a mooring, and in order to ensure that there is a pretension between the rings to keep them together when mooring load is applied, the mooring line bridle is rigged to the trunnions (43) in the manner shown in Figs. 4 and 5. Each of the chains (42), which are bridled to the trunnions (43) at their upper ends, is attached at its lower end via a master link (45) and shackle (46) to a steel plate strap (47) with a boss (48) at its lower end. The boss (48) fits into a recess (49) in a rotating link plate (44). The link plate rotates on a boss (59) which is welded to the suction anchor wall (60) (if necessary via a double plate). The link plate is initially restrained from rotation by a shear pin (61) on a block (62) which is likewise welded to the suction anchor wall. The mooring line bridle chain (51) is likewise connected via a master link (52) and shackle (53) to a steel plate strap (54) carrying a boss (55) at its lower end. The boss (55) fits into a recess in the plate (44) in the same manner as boss (48). Both bosses have heads (50) to prevent them from sliding laterally from the recesses. There are spring strips (63) and (64) to retain the bosses (48) and (55) in their recesses. These spring strips are designed so as to allow the bosses to be pulled from the recesses when the pull applied to them has the appropriate direction and exceeds a given threshold value. There is a short length of loose chain (56) connected between master links (45) and (52) via shackles (57) and (58).

When the suction anchor is installed, the mooring bridle chains (51), which are connected to the mooring leader chain, are vertical at the link plate. However, the tensions applied to the bridle (mainly from the buoy at the top of the leader chain and from soil friction during anchor installation) are insufficient to shear the pin (61). When the mooring leader chain is connected to the main mooring line of the vessel to be moored and the vessel winches in the catenary line, the angle of departure of the bridle moves progressively from the vertical as the tension increases. When the mooring line has reached its operational configuration, the departure slope of the bridle at the link plate is relatively flat (typically 15° to 30° depending on the mooring tension and the seabed soil type). As the mooring tension increases, the shear pin fails and the link plate is free to rotate slightly, though further rotation is prevented by the chain (42) attached to the trunnions (43). The greater the mooring tension, the greater the tension in the chains (42) and hence the greater the pre-tension between the suction anchor rings holding them firmly together and making them act as a unit notwithstanding that they are not welded together. The rings are prevented from horizontal sliding relative to each other by the joint arrangements described in the patent applications referred to above.

When the moored vessel has completed its task on station and the mooring line has been disconnected

from the leader chain, the bridle (51) returns to the vertical at the link plate (44). Since the pin (61) has by now been sheared, any vertical tension on the bridle chain (51) causes the link plate (44) to rotate and increasing tension causes the boss (55) to be pulled from its recess. The short chain (56) then becomes taut and pulls the boss (48) in its turn from its recess. The bridle chains (51) are now directly connected to the trunnions (43) on the top ring (36) by the chains (42). Further winching in and tension on the line thereafter results in the ring extraction sequence shown in Figs. 9, 10, and 11.

Thus, there is a system of devices described herein which provide an arrangement of devices and rigging enabling a mooring line and bridle to be recovered from or with a cylindrical, plate or other form of anchor after use. Furthermore, an arrangement of devices and rigging is described which enables a mooring bridle chain to be detached from an abandoned cylindrical anchor caisson by the application of vertical tension to an actuation chain. Also, the actuation chain may be buoyed off subsea or at sea level. Furthermore, the tension may be applied to the actuation chain by a winch line from a surface vessel, the winch line being attached to the actuation chain by WROV or by diver or at the surface.

In addition, the tension on the actuation chain may shear a shear pin allowing extraction of a tapered

retaining pin thus releasing a spring-loaded stubshaft which withdraws through a journal block and thereby in turn causes the release of the rotating padeye termination of a bridle chain. Furthermore, the device may be attached either to the outside or to the inside of an anchor caisson. Also, the spring-loaded stubshaft holding the bridle chain termination may be inserted with the aid of a hydraulic jack and locked by insertion of a tapered retaining pin prior to anchor deployment.

Furthermore, bosses on the outside of a cylindrical anchor caisson are also described which may enable the caisson to be extracted from the seabed by the application of vertical tension via the mooring chain leader line, mooring chain, and mooring bridle chain.

In addition, the upper bosses may be on opposite sides of the caisson close to its top and both slightly offset in the same direction from the transverse diametral meridian while the lower bosses likewise on opposite sides are still further offset both in the same direction from the plane of the upper bosses. Also, the vertical tension may be applied to the mooring chain leader line by the winch line of a surface vessel. Also, the mooring bridle chains may be attached to the lower bosses on either side of an anchor caisson. Furthermore, the upward tension on the mooring line typically brings the bridle chains into contact with the upper bosses thereby encouraging the vertical axis of the caisson to remain close to vertical during extraction from

the seabed as a result of the fact that rotation due to the vertical soil resistance to extraction automatically generates a restoring couple.

There is also described an arrangement of devices and rigging which may consist of an anchor caisson made up of two or more cylindrical ring sections on top of each other and rigged in such a manner as to enable the anchor ring sections to be extracted sequentially from the seabed by the application of a vertical tension to the mooring line. Furthermore, each ring section may be connected to the next section above or below it by chains attached internally at 120° intervals around the circumference. Also, the mooring bridle chains may be attached to link plates on opposite sides of the lowest ring section, the connection of each chain to its link plate being via a straight steel strap with a boss on one side close to the end and this boss locating into a recess in the edge of the link plate and being retained by a spring-loaded retainer bar. Furthermore, each delta plate may be mounted on a trunnion so that it is free to rotate subject to the shearing of a shear pin. Also, there are typically four bosses at suitable circumferential intervals on the outside near the top of the upper ring section and wherein bridle chains are attached to these bosses via rotating padeyes, one bridle being located on each side of the caisson and with the bridle apex connected via a vertical link chain to the link plate on the lowest ring section with the aid of straps, bosses, and recesses similar to those

connecting the mooring bridle chains to the link plates. In addition, there may be a short length of slightly slack connecting chain between the chain/strap junctions on the bridle chains and link chains at each link plate. Also, any significant tension on the mooring line in its operational orientation may cause the shearing of the shear pins followed by a small rotation of the link plates and a tensioning of the link chains thus holding the several ring sections of the anchor more firmly together the greater the pull on the mooring. Furthermore, a vertical tension on the mooring line after shearing of the shear pins typically results in free rotation of the link plates towards the link chains followed by escape of the strap bosses from their recesses under the influence of tensions which exceed the retaining capacity of the spring-loaded retainer bars and are now acting in directions which cause escape rather than bedding down. Furthermore, further vertical tension on the mooring line typically causes the rigging to reorientate so that the mooring line now pulls upwards on the four bosses on the upper ring section via the bridle arrangements thus initiating extraction of the upper ring section from the seabed. In addition, the internal chains connecting the ring sections are typically of such lengths that the upper ring section is clear of the soil before tension is applied to the second and the second is clear of the soil before tension is applied to the third and so forth thus ensuring that the required tension at any

time is limited to that needed for the extraction of one ring section.

Claims

1. A subsea suction anchor apparatus which, in use, is anchored in a subsea surface, the suction anchor comprising a plurality of portions which are capable of transformation from a first configuration in which the portions are substantially adjacent one another to a second configuration in which the portions are substantially spaced apart from one another such that the suction anchor is capable of being removed from the subsea surface.

2. A subsea suction anchor apparatus according to claim 1, wherein the suction anchor comprises a substantially cylindrical body having a longitudinal axis, and the portions comprise discrete longitudinal lengths of the body.

3. A subsea suction anchor apparatus according to claim 2, wherein the portions of the suction anchor are coupled to one another such that when the suction anchor is in the first configuration, each portion is coincident with the other portions when the suction anchor is in use as a suction anchor, and each portion is adjacent to the closest other portion.

4. A subsea suction anchor apparatus according to any of claims 1 to 3, wherein the portions of the suction anchor are coupled to one another by a coupling means, such that when the suction anchor is in the second configuration, the coupling means

permits the portions to be spaced apart from one another, such that the suction anchor may be removed from the subsea surface.

5. A subsea suction anchor apparatus according to any of claims 1 to 4, wherein an actuation means is provided such that operation of the actuation means permits the transformation of the suction anchor from the first to the second configuration.

6. A subsea suction anchor apparatus according to claim 5, wherein the actuation means comprises a releasable locking means which is coupled to an actuation line, such that an applied force to the actuation line permits release of the locking means.

7. A method of removing a subsea suction anchor from a subsea surface, the method comprising providing a plurality of suction anchor portions which are capable of transformation from a first configuration, in which the portions are substantially adjacent one another and in which the suction anchor is capable of being used as a suction anchor, to a second configuration in which the portions are substantially spaced apart from one another, and transforming the suction anchor from the first to the second configuration such that the suction anchor is capable of being removed from the subsea surface.

8. A method according to claim 7, wherein the suction anchor comprises a substantially cylindrical

body having a longitudinal axis, and the portions comprise discrete longitudinal lengths of the body.

9. A method according to claim 8, wherein the portions of the suction anchor are coupled to one another such that when the suction anchor is in the first configuration, each portion is coincident with the other portions when the suction anchor is in use as a suction anchor, and each portion is adjacent to the closest other portion.

10. A method according to any of claims 7 to 9, wherein the portions of the suction anchor are coupled to one another by a coupling means, such that when the suction anchor is in the second configuration, the coupling means permits the portions to be spaced apart from one another, such that the suction anchor may be removed from the subsea surface.

11. A method according to any of claims 7 to 10, wherein an actuation means is provided such that operation of the actuation means permits the transformation of the suction anchor from the first to the second configuration.

12. A subsea suction anchor apparatus according to claim 11, wherein the actuation means comprises a releasable locking means which is coupled to an actuation line, such that an applied force to the actuation line permits release of the locking means.

13. Apparatus as hereinbefore described with reference to Figs. 9 to 13 of the drawings.

14. A method as hereinbefore described with reference to Figs. 9 to 13 of the drawings.

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Claims searched: 1 to 14

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.T): B7V VHG.

Int Cl (Ed.7): B63B 21/22, 21/24.

Other: Online EPODOC, JAPIO, WPI.

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2317153 A (KARAL) see figures 9 to 13 and related description.	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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